Missouri Department of Natural Resources
Water Pollution Control Program

Total Maximum Daily Loads (TMDLs)

for

Goose and Saline Creeks
Madison County, Missouri

Completed July 22, 1999
Approved December 1, 1999

Goose Creek and Saline Creek (Fredericktown, Missouri)
Final TMDLs (Total Maximum Daily Load)
for Nickel and Cobalt (four TMDLs total)

Name: **Goose Creek**

Missouri WBID No.: 2860

Class: P (Class P streams maintain permanent flow even in drought)

Beneficial Uses: Livestock and Wildlife Watering, Protection of Aquatic Life, Fish Consumption

Size of Impaired Segment: 0.5 miles

Location of Impaired Segment: From the point at which the mine water flow enters the creek in the NW Section 15, T33N, R7E to its confluence with Saline Creek

Pollutants: nickel (documented); cobalt (undocumented but believed possible)

Source: emerging ground waters from the Madison Mine

TMDL Priority: High

Name: **Saline Creek**

Missouri WBID No.: 2859

Class: P (Class P streams maintain permanent flow even in drought)

Beneficial Uses: Livestock and Wildlife Watering, Protection of Aquatic Life, Fish Consumption

Size of Impaired Segment: 0.5 miles

Location of Impaired Segment: From the confluence with Goose Creek in SW Section 10, T33N, R7E, to the SE Section 9, T33N, R7E

Pollutants: Nickel (documented) and Cobalt (undocumented but believed possible)

Source: emerging ground waters from the Madison Mine

TMDL Priority: High

1. Description of Waterbody, Pollutant of Concern, Pollutant Sources and Priority Ranking

Goose and Saline creeks are listed on Missouri's 1998 303(d) list due to high levels of dissolved nickel from emerging underground waters from Madison Mine. Both streams are ranked high on the TMDL priority list. Cobalt is not included in Missouri's 1998 303(d) list as a pollutant for these segments, but two additional TMDLs are developed here for cobalt because the same management practices applied to nickel will correct any impairment caused by cobalt. Because neither Goose nor Saline creek are on Missouri's 1998 Section 303(d) list for cobalt, Missouri is not required to submit these two TMDLs for approval by EPA. Instead, Missouri is providing these two cobalt TMDLs as Section 303(d)(3) TMDLs, which are for Missouri's management and planning purposes.

The beneficial use impaired in these segments is protection of aquatic life.

Lead deposits were first discovered in the Fredericktown area in 1700 at Mine la Motte. Underground mining began at the Madison Mine in 1847, at which time copper was the main metal of interest. This mining ended in 1849 but the mine reopened during the period 1860-1863 during which time lead and copper were mined. Several different companies owned the Madison Mine between 1901 and 1961 and removed lead, copper, cobalt and nickel ores. The mine was purchased by the present owner, Anschutz Mining Corp., in 1979 as a potential source of cobalt ore but the mine was never de-watered and no mining took place.

The Madison Mine is located in portions of Sections 15, 16, 20 and 21, T33N, R7E. The main area of the mine is located about 1 mile southeast of Fredericktown and the southern portion of the mine is located about 2 miles south of Fredericktown. Ground water has flooded most of the mine. The main mine opening from which miners entered and left and ores were removed was called "the decline." This large mine opening is located in the NW Section 15, T33N, R7E. It has an approximate elevation of 750 feet msl and is the main exit point of ground water from the mine. It is identified on topographic maps as a "flowing well." The outflow of mine water from the decline flows eastward about 500 feet where it flows into Goose Creek.

On the surface are several tailings piles and an area of contaminated soil where a metal smelter was once in operation.

Metal bearing minerals in the walls of the flooded mine continue to be dissolved and released into the mine water. Hufham (1981)[1] took several samples of the water flowing from the decline (Site 1 on the map) and some area streams. Missouri DNR took two additional samples from the decline and downstream locations on Goose and Saline creeks in October 1996 and July 1997. Average levels of dissolved metals from these sampling efforts are shown in Table One as are the appropriate Water Quality Standards (bottom line in *italics*), and sampling locations are shown on the attached map.

Table 1 - Mean Levels of Dissolved Metals, (ug/l) and the last row in the Table gives the state water quality standard chronic value for protection of aquatic life. See map for site locations.

[1.] A Baseline Study of the Heavy Metal Content of Open Waters at Fredericktown, Missouri, Hufham, J. 1981. University of Missouri-Rolla. Rolla, Mo.

Source	Site	Mean Dissolved Metals in Ug/L						
		Nickel	Cobalt	Iron	Lead	Copper	Cd.	Zinc
Hufham	1	4600	3750	42	10	9	2	
Mo. DNR	1	3270	2385		<10	12		145
Hufham	2		4	13	2	4	<1	
Mo. DNR	3	**1042**	686		<10	6		123
Hufham	4	270	120	20	3	6	<1	
Mo. DNR	5	214	66		<10	<12		44
WQ Std.		***500***	***1000***	***1000***	***16***	***28***	***11.8***	***340***

The only exceedence of water quality standards documented by these studies is for nickel in Goose Creek (in bold).

Flows from the mine vary somewhat due to the timing and amount of local rainfall, but 0.5-0.7 cfs is a typical range of flows during drier weather. Given the concentrations of nickel and cobalt emerging from the mine and the estimated 7Q10 low flow of both Goose Creek and Saline Creek above Goose Creek, 0.1 cfs each, both nickel and cobalt would appear to exceed water quality standards at the 7Q10 low flow.

Concentrations of lead, copper, cadmium, and zinc in the mine water discharge are less than water quality standards.

In-stream dissolved metals concentrations during wet weather appear to be substantially less, due primarily to dilution by surface flows in Goose and Saline creeks. A storm water quality survey[2] sampled four storm water events in April and May of 1996. Mean levels of dissolved metals at a station on Saline Creek, at about the same location as Site 5, showed nickel and cobalt concentrations only about 12-25% of what Missouri DNR reported. Average amounts reported on Saline Creek during this survey were as follows (in ug/l): nickel 55, cobalt 18, zinc <100, copper <10, lead <5.

2. Description of the Applicable Water Quality Standards and Numeric Water Quality Target

The beneficial uses for Goose and Saline creeks are Livestock and Wildlife Watering, Protection of Aquatic Life and Human Health Protection - Fish Consumption. The Protection of Aquatic Life use is impaired in these segments.

The applicable water quality standards for nickel and cobalt are: Nickel, 500 ug/l as dissolved metal for protection of aquatic life. Cobalt, 1000 ug/l as dissolved metal for protection of aquatic life. Missouri's Water Quality Standards include the EPA "three-tiered" approach to anti-degradation. Tier I defines baseline conditions for all waters -- it requires that existing beneficial uses are protected. TMDLs would normally be based on this tier, assuring that numeric criteria (such as dissolved oxygen,

[2] Madison Mine: Site Stabilization Report. 1996. Terranext Corp. for Anschutz Mining Corp.

ammonia) are met to protect uses. Tier II requires no degradation of high-quality waters, unless limited lowering of quality is shown to be necessary for "economic and social development." A clear implementation policy for this tier has not been developed, although if sufficient data on high-quality waters are available, TMDLs could be based on maintaining existing conditions, rather than the minimal Tier I criteria. Tier III (the most stringent tier) applies to waters designated in the water quality standards as outstanding state and national resource waters; Tier III requires no degradation under any conditions. Management may require no discharge or prohibition certain polluting activities. TMDLs would need to assure no measurable increase in pollutant loading. These TMDLs satisfies Tier I of Missouri's anti-degradation policy, since after these TMDLs have been implemented, water quality in the impaired segments will be improved and meet the applicable standards, and the beneficial uses will be protected.

3. Loading Capacity – Linking Water Quality and Pollutant Sources

Load capacity is defined as the greatest amount of a pollutant a waterbody can receive without violating Water Quality Standards. Missouri's Water Quality Standards, 10CSR20-7.031 in section (4)(A)1 notes that when permanent stream flows are less than the 7Q10 low flow value (the lowest average flow for seven consecutive days with a recurrence interval of ten years), water quality standards do not apply. Missouri DNR has used this section of the standards to define critical (worst case flow conditions, or design flow conditions) flow for point source discharge of pollutants to be the 7Q10 low flow.

Load calculations for Goose and Saline creeks are made in pounds/day using the formula:

(Concentration in mg/l)(flow in cu. feet/second)(5.4) = Pounds/day (1)

Load calculations are made assuming extremely dry weather conditions when streams are least able to dilute the mine water flow from the decline. The design flow condition used is the 7Q10 low flow. This value has not been determined for either Goose or Saline creek since there is insufficient flow information on these streams. However, they are listed as permanently flowing streams in Missouri's Water Quality Standards based upon many observations made by local Department of Conservation personnel. For the purpose of this load calculation, a 7Q10 flow in Goose Creek is assumed to be 0.1 cfs, and a 7Q10 flow in Saline Creek is assumed to be 0.2 cfs (0.1 cfs from Goose Creek plus 0.1 cfs from Saline Creek upstream of the confluence with Goose Creek).

Thus, the design flow for Goose Creek downstream of the mine discharge is the sum of the upstream 7Q10 low flow of Goose Creek, 0.1 cfs, and the estimated dry weather flow from the decline which is estimated at 0.5 to 0.7 cfs. To contribute to the margin of safety, the high end of this mine flow range will be used because this flow would result in the highest concentration of nickel and cobalt in the stream. Thus, the design flow in Goose Creek is 0.1 + 0.7 = 0.8 cfs. Likewise, the design flow for Saline Creek is 0.9 cfs.

The load capacity for dissolved nickel in Goose Creek below the mine water discharge (in pounds/day) is the amount that will result in an in-stream concentration equal to the water quality standard (500 ug/l or 0.5 mg/l) when the stream flow downstream of the mine water discharge is 0.8 cfs. The calculation is the same for dissolved cobalt except that the water quality standard is 1.0 mg/l.

Using Formula 1(above):

Load Capacity: Goose Creek

(0.5 mg/l dissolved Ni)(0.8 cfs)(5.4) = 2.160 pounds dissolved nickel per day
(1.0 mg/l dissolved Co)(0.8 cfs)(5.4) = 4.320 pounds dissolved cobalt per day

Load Capacity: Saline Creek

(0.5 mg/l dissolved Ni)(0.9cfs)(5.4) = 2.43 pounds per day dissolved nickel
(1.0 mg/l dissolved Co)(0.9cfs)(5.4) = 4.86 pounds per day dissolved cobalt

4. Load Allocations

The nonpoint source load allocation for Goose and Saline creeks are estimated using an estimated 7Q10 low flow of 0.1 cfs in both streams and average nickel and cobalt concentrations[3] and Formula 1 give:

(0.004 mg/l)(0.1 cfs)(5.4) = 0.002 pounds/day

for each metal in each stream.

5. Wasteload Allocation

The maximum permissible Waste Load Allocation for Goose Creek is determined by the formula:

(*Load Capacity) - (Nonpoint Load Allocation) - (Margin of Safety) - (Held in Reserve) = Point Wasteload Allocation (2)*

A Margin of Safety of 10% of the Load Capacity was selected (see below).

In addition to the Margin of Safety on Saline Creek, approximately 11% of the load capacity (0.243 #/day nickel and 0.486 #/day cobalt) will be held in reserve for future development.

Thus, Formula 2 yields the following Wasteload Allocations for nickel and cobalt:

Goose Creek: Nickel (2.160) - (0.002) - (0.216) - (0) = 1.942 pounds/day.
Cobalt (4.320) - (0.002) - (0.432) - (0) = 3.886 pounds/day.

Saline Creek: Nickel (2.160) - (0.002) - (0.216) - (0.243) = 1.699 pounds/day.
Cobalt (4.320) - (0.002) - (0.432) - (0.486) = 3.4 pounds/day.

[3] Water quality monitoring by the USGS statewide shows dissolved Cobalt and Nickel concentrations average 2-3 ug/l. Hufham found average dissolved Cobalt and Nickel concentrations in Goose Creek upstream of the mine discharge averaged 4 ug/l.

6. Margin of Safety

There was insufficient data and other information to establish the uncertainty in our knowledge of the loading capacity of these segments. As a result, a Margin of Safety of 10% of the Load Capacity was selected for both Goose and Saline creeks. These values in pounds/day are:

Goose Creek:	Nickel 0.216	Cobalt 0.432
Saline Creek:	Nickel 0.243	Cobalt 0.486

As mentioned in the implementation plan for these TMDLs (see below), an NPDES permit was issued to control the discharge containing nickel and cobalt in June 1997, which is considered as Phase I of these TMDLs (even though the permit predates these TMDLs). If future monitoring indicates that applicable water quality standards are exceeded for these segments, then these TMDLs will be reopened, and the Margin of Safety will be re-evaluated based on more data and other information.

7. Seasonal Variation

Seasonal variation of mineralization of mine waters is not considered to occur due to the consistency of water temperatures in the mine throughout the year. The major seasonal variation expected with regard to the mine water discharge would be the volume of flow which would be expected to be somewhat greater during the wetter seasons (i.e., late fall through spring). These increased mine water flows would be offset by increased surface water diluting flows and during the wetter periods of the year, we would expect the ratio of surface water to mine water flows to be much greater than the 1:7 ratio used in this TMDL.

These greater ratios of surface to mine water would mean much more dilution of nickel and cobalt in the streams during wet weather. This assumption is supported by wet weather water quality sampling (see last paragraph, Section 3). Since there is no evidence to link the observed impairment with the seasons, seasonality is not considered to be important in these TMDLs.

8. Monitoring Plan for TMDLs Developed under the Phased Approach

The Goose Creek and Saline Creek TMDLs for nickel and cobalt are phased TMDLs. If the monitoring program outlined below finds exceedences of water quality standards still occur after Phase I implementation, further reductions in nickel and cobalt loads originating from the Madison Mine (and or other discovered sources) would be required through amendment of the NPDES permit.

The NPDES permit requires both storm water and dry weather in-stream monitoring of Goose Creek below the mine water discharge on a regular basis as well as regular monitoring of the mine water discharge with all results reported to the Missouri DNR. In addition, Missouri DNR plans a triennial water quality survey of Goose and Saline creeks during dry weather to confirm that in-stream water quality standards are being achieved during these low flow conditions.

9. Implementation Plans

These three TMDLs will be incorporated into Missouri's Water Quality Management Plan.

NPDES Permit MO-0098752 was issued to Anschutz Mining Corporation by the Water Pollution Control Program of Missouri DNR in June 1997 (see attached). The purpose of the permit was to provide Anschutz with a schedule for compliance for treating waters discharged from the Madison Mine property. Included in this permit is a requirement that discharges of mine water from the decline shall not exceed 500 ug/l dissolved nickel and 1000 ug/l dissolved cobalt. At the assumed design mine flow of 0.7 cfs, this permit would allow:

(0.5 mg/l)(0.7 cfs)(5.4) = 1.89 pounds/day dissolved nickel; and
(1 mg/l)(0.7 cfs)(5.4) = 3.78 pounds/day dissolved cobalt.

These values are both slightly less than the allowable loads calculated above for Goose Creek (dissolved nickel 1.942 pounds/day and dissolved cobalt 3.886 pounds/day), but slightly more than the cobalt and nickel wasteload allocation for Saline Creek. The two cobalt TMDLs are Section 303(d)(3) TMDLs, which do not require EPA review and approval.

The nickel TMDLs are phased and since the NPDES permit limits were issued before these TMDLs were developed, these limits will be allowed to remain in effect until future monitoring indicates whether or not applicable water quality standards are met. If monitoring data and other information indicate that Saline Creek is impaired, then Phase II will re-evaluate the permit limits and take corrective action as appropriate.

The present permit calls for these water quality based limits to be effective in June 2000.

10. Reasonable Assurances

The NPDES permit controls the loading the permittee is allowed to discharge. Authority of the NPDES permit provides reasonable assurance of compliance with permit limits.

11. Public Participation

The Missouri Department of Natural Resources, Division of Environmental Quality, Water Pollution Control Program, developed this TMDL. The TMDL was placed on public notice from March 19 to April 23, 1999. No comments were received. Six public meetings to allow input from the public on impaired waters were held between August 18 and September 22, 1999. No comments pertaining to Goose or Saline creeks were received during the public notice or the public meetings.

12. Administrative Record

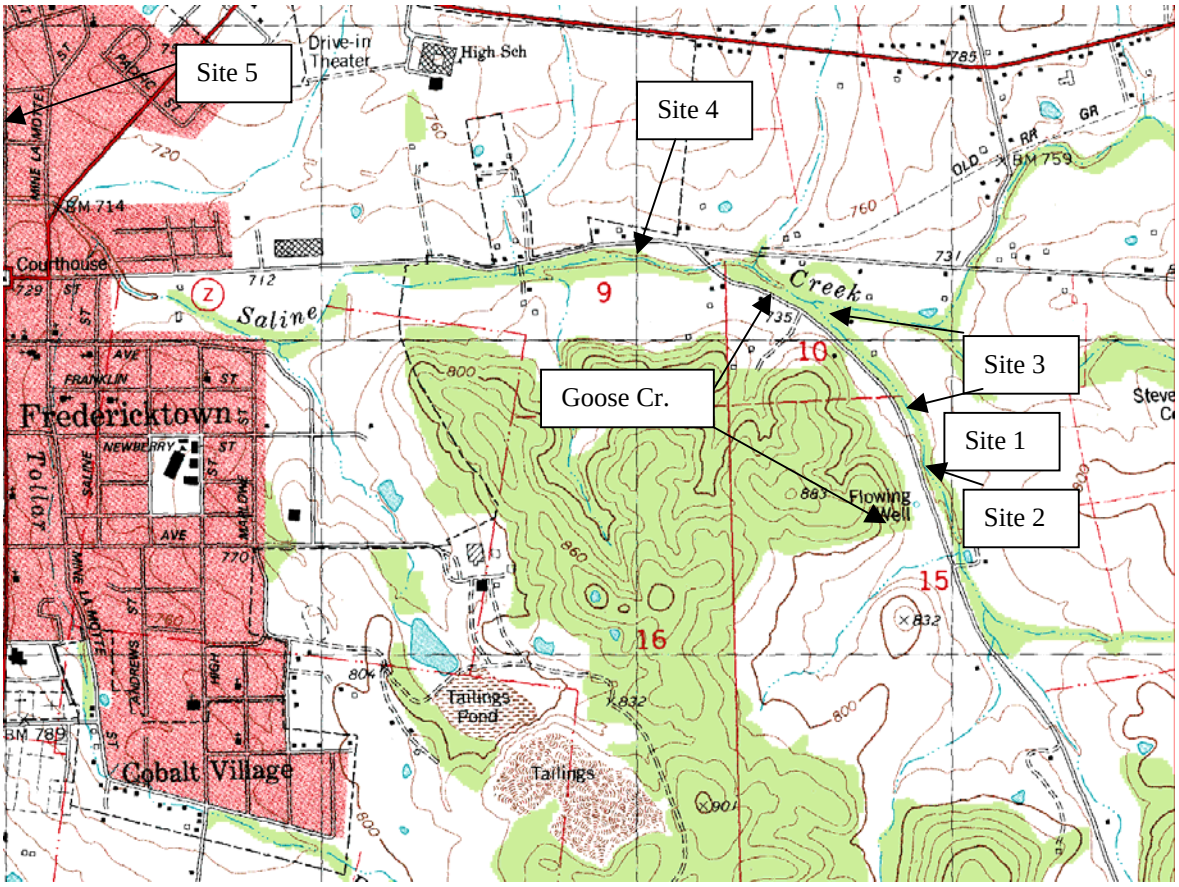
An Administrative Record is being maintained by the Missouri DNR for these four TMDLs.

References Maintained as Administrative Record

1. Map of Saline and Goose Creeks
2. NPDES permit MO-0098752
3. A Baseline Study of the Heavy Metal Content of Open Waters at Fredericktown, Missouri, Hufham, J. 1981. University of Missouri-Rolla. Rolla, Mo.
4. Madison Mine: Site Stabilization Report. 1996. Terranext Corp. for Anschutz Mining Corp.

Appendix A

Map of Saline and Goose Creeks, Fredericktown, Missouri



Site 1. Flow from Mine
Site 2. Goose Creek upstream of Mine flow
Site 3. Goose Creek 0.25 miles downstream of Mine flow
Site 4. Saline Creek just downstream of Goose Creek
Site 5. Saline Creek 1.5 miles downstream of Goose Creek